BuildingIQ

New Approaches in Automating and Optimizing Demand Response to Solve Peak Load Management Problems

WHITE PAPER

Abstract

Peak loads and increasing imbalances between electricity supply and demand are creating management challenges for utilities. These challenges are increasingly being resolved by demand-side rather than supply-side solutions. While the use of curtailable load in Demand Response (DR) applications is a powerful tool in managing the problem of grid load peaks, it is not without problems. Delivering DR from commercial, industrial and institutional (C/I/I) buildings can be difficult, costly and risky for building owners. DR participation from these electricity customers can be unreliable and unpredictable unless the right tools, processes, economic incentives, and training are in place.

This paper discusses how automated and optimized DR technology can establish meaningful and accurate relationships between DR lead-time, incentives, DR duration, external environmental conditions and building occupancy. The key is understanding the HVAC capacity and thermal characteristics of a building. New technologies provide utilities better insight into potential and available customer DR resources. These new technologies automatically inform utilities of the future load profiles of buildings enrolled in DR programs – allowing utilities to better plan grid operations before a critical peak event occurs.

Market Needs & Motivations

Emission regulations, renewable portfolio standards, reliability concerns, variable supply options , transmission constraints and interconnection are driving the large-scale deployment of new infrastructure capabilities, such as the smart grid, dynamic pricing, and demand-response programs.

The need for time-of-use pricing and more price-responsive (elastic) demand is forcing the deployment of advanced energy management systems in residential and commercial buildings.

Optimizing the operation of Heating Ventilation and Cooling (HVAC) systems is one of the most critical requirements, since HVAC systems account for 30-40% of the total energy demand in buildings[1] in the U.S.

1. The Case for Predictive Optimization Energy Software

Current State:

Existing Building Management Systems (BMS) serve as the interface for building operators by monitoring sensor data and modifying operational (set-point) conditions for airhandling units, thermostats, chillers, and boilers as conditions change, such as occupancy, external weather, and energy prices. BMS systems are equipped with basic controllers that track the set-points. These may include basic optimization

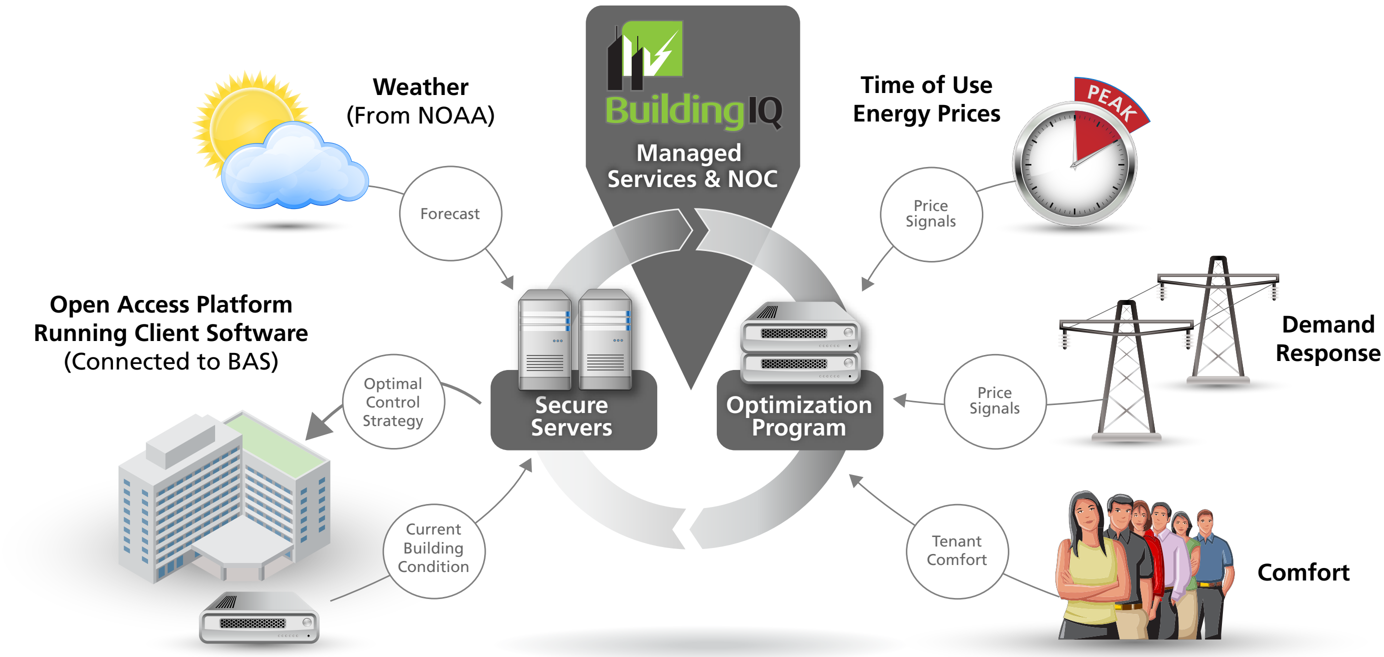

Figure 1—System Overview *shows the software linkage between BuildingIQ's Predictive Energy Optimization System and the building's existing BMS. Optimization includes building thermal modeling, comfort modeling, and DR management.*

functions to minimize energy consumption and cost by using pre-cooling and economizers. The BMS' human operator typically makes the economic and operational decisions in the building. This process is usually reactive in nature and is based on historical experience. Such methods can be inefficient, since weather and energy market conditions are highly dynamic. BMS operators have access to very limited real-time information about pending weather, building energy loads and market prices.

This lack of systematic knowledge and the inability of the BMS mechanisms to accurately quantify and anticipate the effect of weather, occupancy, building design, and market prices hinder the building's dynamic response. They expose a building to highly volatile real-time prices and increased costs. They limit the building's ability to participate strategically in electricity markets.

Limited building knowledge and the lack of predictive abilities also increase the supply requirements of the serving utility. As a result, utilities see sporadic and inconsistent participation in demand response when and where they most need it. Utilities typically have inaccurate data as to what demand reductions a given building can deliver.

New Approaches by BuildingIQ:

Predictive modeling and system control software has been shown to reduce ongoing HVAC energy consumption 15-40% , and peak loads up to 30% during DR events. BuildingIQ installations include office buildings, retail malls, utility programs and U.S. Dept. of Energy Facilities.

Predictive building management systems make use of weather forecasts, energy price signals and predictive dynamic models of the building to anticipate trends that minimize the building's HVAC requirements. The key principle is that the building has sufficient momentum or thermal mass to offset the conditioned space requirements over extended periods of time without affecting comfort conditions. This "coordination principle" is key to both saving energy and to leveling cooling demands throughout the day[2].

1.1 Key Attributes of the Solution

The solution requires software that can learn a building's thermal dynamics and occupancy patterns. When coupled with internal/external data— such as real-time and "ahead" energy pricing, utility incentives, and realtime/forecasted weather— the system optimizes the settings of the building management system (BMS) to reduce energy and/or cost while maintaining comfort. The solution:

- Plugs into virtually any BMS in new or existing buildings, thus leveraging existing infrastructure and reducing installation and operating costs (via BacNet, OPC, Tridium JACE, etc.)
- Interfaces with Utility Automated Demand Response programs via OpenADR protocols.
- Utilizes software only; no system upgrades or new sensors are (generally) required.
- Affords building and multi-building (portfolio-level) capabilities for aggregation of DR or allocation of DR commitments.
- Creates a subscription-based solution, requiring no up-front capital by end-user or utility.

Predictive, Adaptive, Continuous Optimization of building energy consumption are hallmarks of the system.

- Key inputs:
  - Existing building data.
  - Historical, real-time and forecasted external data (utility pricing, weather).
  - Tenant/Occupant feedback (zone temps, etc.)
- Creates a unique model of building dynamics (32 key attributes), which is refined continosly.
- Model establishes a building operating profile; algorithms optimize performance.
- Optimized forecast drives BMS inputs; continuously updated.
- Tenant/Occupant comfort is the key input in optimization strategies and implementation (using ASHRAE 90.1 and 55 comfort model).

The system modeling learns the building's characteristics and operating parameters.

- Unlike EnergyPlus, the model is not structural.
- Uses dynamic systems theory and time series analysis.

After the system modeling learns the building's characteristics and operating parameters, it then goes into an active operational mode with constant updates and system adjustments during the various seasons.

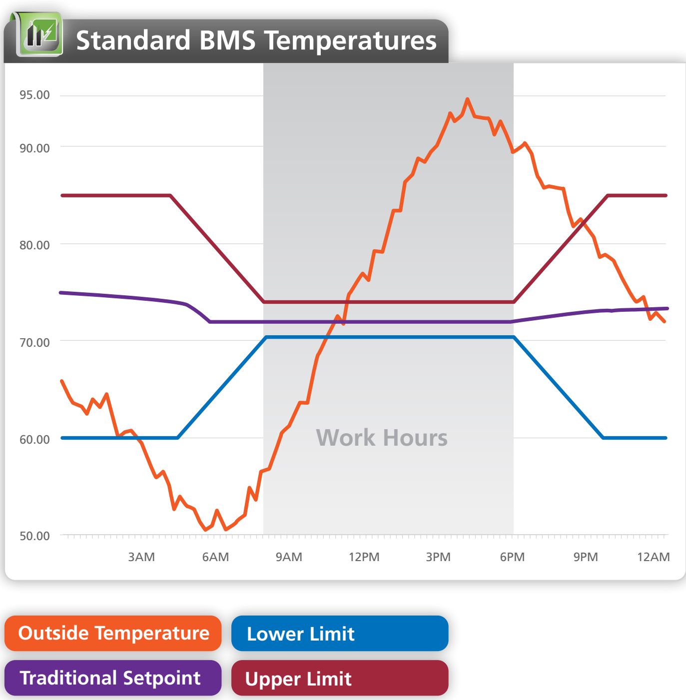

Figure 2—Standard BMS Temperature *shows the traditional HVAC temperature setpoint of BMS is unvarying, and set midway between the upper and lower limits.*

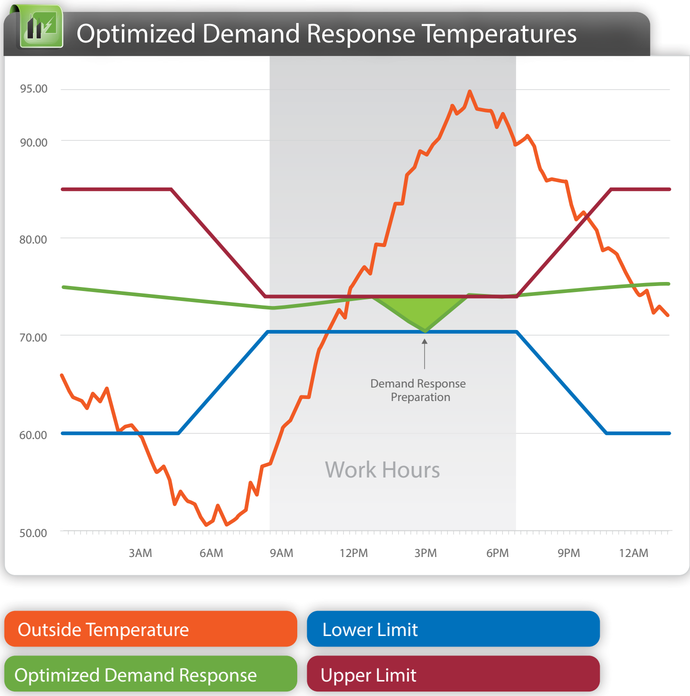

Figure 3—Optimized Demand Response Temperature *shows that demand reduction during peak hours is possible, while still maintaining office temperatures in the comfort zone during work hours.*

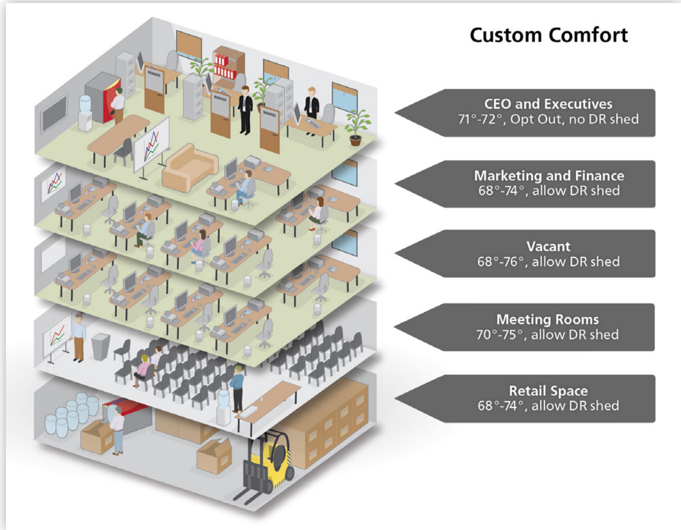

Figure 4—Custom Comfort *shows how comfort levels and DR can be tailored to occupants needs, in this case stratified by floors. The executive level has the narrowest temperature band, and does not participate in load shedding events. At the other extreme, the vacant floor has the widest temperature band and does participate in load shedding.*

The system can utilize "comfort" as the primary governing factor if this attribute is more important to the building owners or operators than energy cost or energy consumption.

The system operates and fine-tunes itself within the existing control system deadbands, throttling ranges. It may do setpoint adjustments within permissible parameters.

Figure 5—Customer Hierarchy of Needs *shows how optimization is structured according to the customers' priorities. In this case, tenant comfort is the highest, followed by DR capability, energy efficiency reductions, and price response.*

1.2 What Does the System Read and Control?

Not all BMS points are "mapped" into the predictive model and control system; only key system points are used. Ideally, the building will have Direct Digital Control (DDC) of the BMS sub-components at the AHU level. Power meter information can be collected through the BMS, independent metering or by web services connections to other sources such as the utility.

The system incorporates interactions with key BMS elements to "trim" and/or fine tune HVAC operations. Operating strategies for satisfying occupant space needs can include such initiatives as use of increased Air Handler static pressure in lieu of Chiller generated BTUs.

2. Automated Demand Response

Additional savings and results can be achieved by implementing automated demand-response control optimization strategies.

Predictive Energy Optimization provides building managers and owners some unique strategies and tactics to improve DR program participation, such as:

- Improved understanding of the building's capacity to shed load.
- Improved understanding of the energy, cost and comfort impact of a DR event before the event.
- Optimizing the building operations around the DR event.
- Synchronizing electronic signals from the utility with the BuildingIQ system and the BMS. DR event(s) are thus automatically incorporated into optimization parameters.
- Planning the building's response for DR events that are tailored to the building's unique design, the building's Tenant comfort parameters, weather and the specific DR program structure/elements.
- Having the building adapt in real-time to changes in internal and external conditions.
- Real-time tracking of impact and results.

2.1 Optimized Demand Response

Incorporation of optimized, automatic DR can:

- Improve the value proposition of the DR program participation for building owners.
  - Automate communications, and the management and reporting of Demand Response events (OpenADR, AutoDR and web-based signals).
  - Minimize tenant/occupant comfort impact.
  - Minimize Peak Day Pricing penalties.
  - Manage buildings on an individual or aggregate basis to share load.
- Optimization offer utilities insight into the peak –demand resources at the far "Edge of the SmartGrid" by providing:
  - A detailed understanding of the building's consumption history, trends and dynamics.
  - An ability to forecast demand at the building level (day-ahead or 4-hours ahead, etc.).
  - An ability to run demand scenarios based on weather, pricing and comfort requirements.
  - An ability to forecast demand at different levels—the aggregated portfolio, a distribution circuit or a specific geography.

3. Typical Results

- 10-25% HVAC Energy Savings, and
- 10-20% Demand Savings.

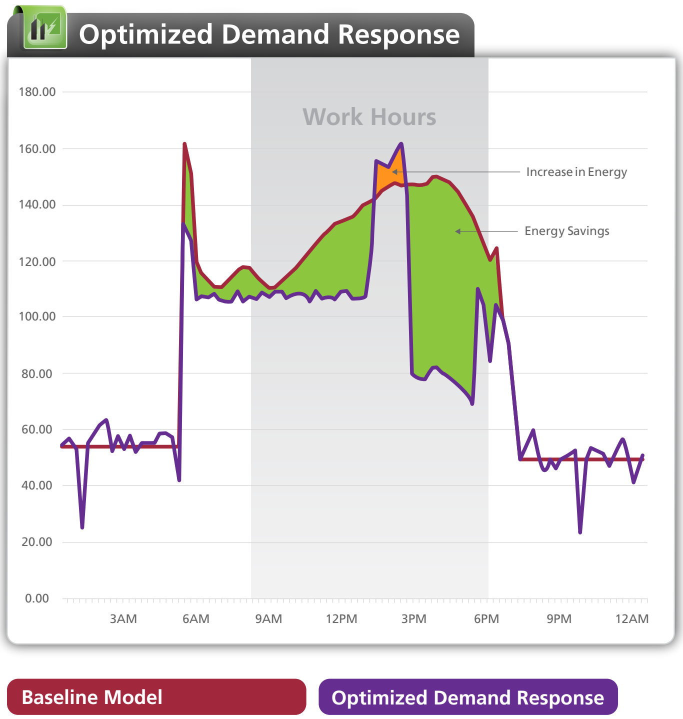

Figure 6—Optimized Demand Response *contrast energy consumption during baseline operations (business as ususual) with energy consumption over the same period of time using an optimized demand response program. The shaded green shows that savings from optimization are greatest during afternoon peak load.*

Buildings implementing predictive modeling and control strategies have seen a variety of other returns and improvements, including:

- Increases of 5-10 Energy Star Points are typical.
- Provides positive cash-flow from month 2.
- Retention of tenants, property values and capital equipment life extensions.

The chart below depicts actual savings from an installed Predictive Modeling and Control system in New York City. This system is working with an existing DDC-based BMS in a Class "A" multi- tenant office complex in a fully deregulated market, with volatile energy price exposure.

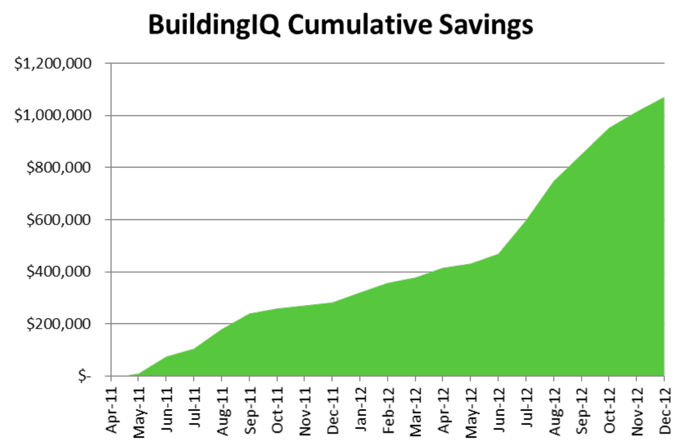

Figure 8—Specific Savings Example *shows the actual savings from an installed BuildingIQ Predictive Modeling and Control system in a Class-A office complex in New York City.*

ENERGY STAR® Rating		Gross Annual Savings		Property Value Impact @ 8% cap rate		Pay-Back Months
Before	After	200k ft² $36k Cost	500k ft² $90k Cost	200k ft²	500k ft²	
95	96	$60,765	$151,914	$815,946	$2,039,866	7
90	93	$72,325	$180,812	$1,056,767	$2,641,916	6
85	89	$81,377	$203,444	$1,245,364	$3,113,411	5
80	85	$89,269	$223,174	$1,409,780	$3,524,450	5
75	80	$96,530	$241,324	$1,561,031	$3,902,579	4

Table 1—Sample Savings Results *shows the time and scale of investment payback using the BuildingIQ system. In this example, positive cash flow begins within six months, and the ROI is in the order of 500%—$5 in savings for every dollar in subscription fees.*

4. Summary

Use of predictive modeling/control tools in conjunction with existing BMS has proven to be a very effective tool for C/I/I building owner/operators, as well as occupants and utilities, to minimize operational costs, avoid capital expenditures and improve comfort. Highlights include:

- Strong stand-alone ROI (with or without utility incentives/rebates or tax credits).
- Improved value proposition for building owners to participate in DR programs.
- Unique insight for utilities into the peak-demand, customer-based resources at the "Edge of the SmartGrid".
- New revenue sources for property owners/ managers.
- Retention of tenants and property values.
- Open, BMS vendor & HVAC manufacturer "neutral" solutions.

Reference Citations

1. U.S. Department of Energy's Energy Information Administration ("EIA") www.eia.doe.gov
2. J. K. Ward, J. Wall, S. West, and R. de Dear. Beyond comfort managing the impact of HVAC control on the outside world. In Proceedings of Conference: Air Conditioning and the Low Carbon Cooling Challenge, 2008.

About BuildingIQ

BuildingIQ provides advanced, cloud-based software to reduce HVAC costs in commercial buildings. Customers save 10-25% of HVAC energy and can add 20 points to their LEED score. BuildingIQ software continuously monitors inputs including weather forecast, occupancy, energy prices and demand response events. It makes small changes in HVAC settings that result in large financial gains without impacting occupant comfort.

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